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# Renal stones First steps and keys to reducing recurrence

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# Renal stones First steps and keys to reducing recurrence

## **Abstract**

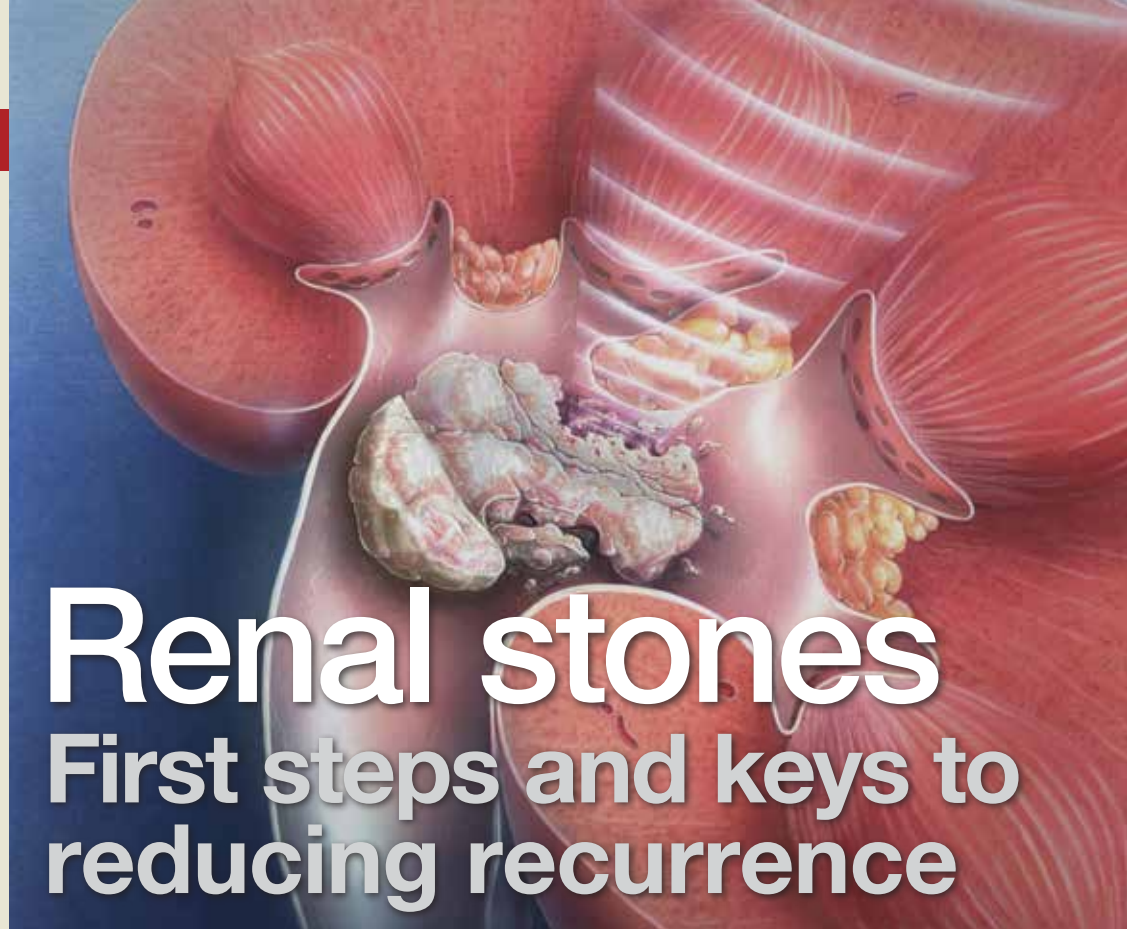
In patients with a renal stone, management aims to detect complications, triage to expectant observation or active intervention and identify any predisposing factors. Referral for active urological intervention or detailed metabolic evaluation may be indicated. Dietary and lifestyle interventions may help decrease the risk of recurrences.

## **Disciplines**

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# Renal stones

## First steps and keys to reducing recurrence

### Key points

- In patients with a suspected renal stone, history taking, examination and investigation aim to confirm the diagnosis and detect any complications, such as sepsis or renal damage, and underlying factors that increase the risk of recurrence.
- Options for treatment of renal stones include expectant observation if the patient has good renal function, well-controlled pain and no evidence of sepsis, or a need for active urological intervention.
- Urinary tract infection in the presence of obstruction is a medical and surgical emergency, requiring immediate relief of the obstruction.
- Factors that contribute to renal stone formation should be addressed to prevent further stones; the most important lifestyle interventions are increased water intake and reduced protein and sodium intake.

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In patients with a renal stone, management aims to detect complications, triage to expectant observation or active intervention and identify any predisposing factors. Referral for active urological intervention or detailed metabolic evaluation may be indicated. Dietary and lifestyle interventions may help decrease the risk of recurrences.

**R**enal stones are common and are associated with significant morbidity and, on rare occasions, mortality when the stone obstructs the urinary tract in the presence of infected urine. Common adverse impacts of renal stones (calculi) include not only pain but also the need for GP or emergency department visits for pain relief or intervention, surgical procedures, follow-up reviews and time lost from work. Renal stones are associated with an increased risk of chronic renal disease. In addition, people who develop renal stones are at increased risk of cardiovascular events, hypertension, diabetes and the metabolic syndrome. For those with

recurrent stone disease, the risks associated with repeated radiation exposure from imaging studies must also be considered.

Lifestyle factors can contribute to the risk of stone formation, and addressing these may reduce recurrences. Some patients, however, have more complex metabolic abnormalities or underlying medical conditions that may require specific management by renal physicians or urologists with a special interest in this area. This article discusses the approach to evaluation, treatment and referral of patients with renal stones in general practice. It will not address surgical management in detail.

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Figures 1a and b. a (above). Renal stones (scale in cm). b (right). Radiograph showing a staghorn renal calculus in the right kidney.



## EPIDEMIOLOGY

Renal stones range from asymptomatic small stones to large, obstructing staghorn calculi that impair renal function and cause chronic kidney disease (Figures 1a and b). The presence of renal stone disease of any kind increases the risk of chronic renal impairment.

Estimates of the incidence of renal stone disease vary between populations; in the USA, an estimated 12% of men and 5% of women will have a renal stone that causes symptoms by the age of 70 years. The overall incidence of renal stone disease, as well as the proportion of females affected, are reported to be increasing, probably related to changes in diet and lifestyle. The incidence also varies with geography, climate and seasonal factors, with a higher incidence in hotter drier environments, related to the greater risk of dehydration.<sup>1,2</sup>

Australian data on the incidence of renal stones are limited. A study using the Western Australia Linked Database reported that between 1980 and 1997 almost 17,000 patients were admitted to hospital after a first presentation with a principal condition relating to renal or ureteric stones.<sup>3</sup> The mean age was 48 years (range, 1 to 95 years), and 70% were males. More than half the patients were admitted as emergency cases, and 55% underwent at least one surgical intervention, with almost a quarter

undergoing multiple procedures by mid-1999. There were more than 12,000 hospital readmissions, almost half for recurrence of upper urinary tract stones. The locations of the renal stones were in the ureter alone (54%), in the kidney alone (42%) and in several sites involving both the kidney and ureter (4%).

Small Australian case series report an increased incidence of renal stones in children in rural and remote areas related to diet and dehydration as well as chronic metabolic acidosis complicating diarrhoeal illnesses.<sup>4,5</sup>

The risk of recurrence of renal stones has been estimated as 50% within 10 years. Males have a higher recurrence rate than females. The risk of repeat stones is highest in the year immediately after the first episode. For calcium stones, the risk of a second stone has been reported to be 15% at one year, 35 to 40% at five years and 80% at 10 years.

Observational studies have linked renal stones with diabetes, hypertension, obesity, hyperuricaemia, hyperlipidaemia, chronic kidney disease and cardiovascular disease. A 2014 meta-analysis of cohort studies concluded that kidney stones are a risk factor for both stroke and coronary heart disease.<sup>6</sup> The risk of an adverse cardiovascular event may be higher for women than men, but long-term prospective studies are needed to investigate the sex-specific association.

## AETIOLOGY OF RENAL STONES

Renal stones develop when crystals form in the urine and subsequently grow. This occurs when the urine becomes supersaturated with salts such as calcium oxalate, sodium urate, magnesium ammonium phosphate or cystine (i.e. the amount of the salt exceeds its solubility). Crystals can also form when concentrations of inhibitors to crystallisation are low or matrix (a mucoprotein) is present.<sup>7</sup> Inhibitors of crystallisation include citrate, magnesium, zinc and pyrophosphate, as well as the glycoproteins nephrocalcin and Tamm–Horsfall protein.

The risk of stone formation can be reduced by modifying the concentration or solubility of the crystallising substance. Manipulation of risk factors is crucial to preventing recurrent stone formation. Patients may have one or multiple factors contributing to stone formation.

Renal stones are most commonly composed of calcium, generally combined with oxalate but also phosphate. Calcium stones may occur with the following abnormalities, alone or in combination:

- hypercalciuria with or without hypercalcaemia
- hyperuricosuria (uric acid acts as the nidus for the stone formation)
- hypocitraturia
- hyperoxaluria
- low urine volume.

Other types of renal stones are composed of uric acid, struvite (magnesium ammonium phosphate, sometimes termed infection or triple phosphate stones, which form in the presence of urea-splitting micro-organisms), cystine or a mixture (calcium, oxalate and urate). A NSW study of upper urinary stones submitted for analysis between 2009 and 2011 found they were composed of calcium oxalate (64%), uric acid (16%) or struvite (7%).<sup>8</sup> The peak incidence of struvite stones was in men aged 61 to 70 years.

Medical conditions and medications associated with an increased risk of stone formation are listed in Box 1. Lifestyle factors that increase the risk of renal stones are discussed below.

© FIG 1A: AIRBORNETT/DOLLAR PHOTO CLUB; FIG 1B: STOCK DEVIL/STOCKPHOTO

## 1. MEDICAL CONDITIONS THAT INCREASE RISK OF RENAL STONE FORMATION

### Increased absorption of oxalate from the gastrointestinal tract

- Short bowel syndrome
- Chronic diarrhoea
- Past bowel surgery
- Jejunioileal bypass surgery
- Inflammatory bowel disease (Crohn's disease, ulcerative colitis)

### Increased risk of urinary tract infections

- Spinal cord injury

### Increased urinary calcium excretion

- Primary hyperparathyroidism
- Sarcoidosis

### Increased uric acid production

- Psoriasis (rapid cell turnover)

### Renal tubular acidosis

- Sjögren's disease

### Medications

- Carbonic anhydrase inhibitors (e.g. acetazolamide)
- Topiramate
- Frusemide
- Vitamin C
- Vitamin D excess
- Laxatives
- Sulfonamides
- Triamterene
- Indinavir

### Anatomical abnormalities

- Tubular ectasia – medullary sponge kidney
- Pelviureteric junction obstruction
- Calyceal diverticulum, calyceal cyst
- Ureteral stricture
- Horseshoe kidney
- Ileal conduits
- Long-term indwelling catheters

## 2. DIFFERENTIAL DIAGNOSES FOR RENAL COLIC

### Gynaecological

- Haemorrhagic ovarian cyst
- Dermoid cyst
- Endometrioma
- Ovarian neoplasm
- Ovarian torsion
- Fibroid
- Ectopic pregnancy
- Pelvic inflammatory disease

### Gastrointestinal

- Appendicitis
- Diverticulitis
- Biliary disorders
- Pancreatitis
- Small bowel obstruction

### Urological

- Pyelonephritis
- Urinary tract infection

### Vascular

- Abdominal aortic aneurysm
- Aortic dissection
- Renal artery thrombosis
- Renal infarction
- Mesenteric artery dissection or embolism
- Intraperitoneal or retroperitoneal haemorrhage

### Musculoskeletal

- Mechanical low back pain
- Fractures

### Other

- Herpes zoster (shingles)

## PRESENTATION

The typical presentation of renal stones is sudden onset of unilateral flank pain that radiates to the groin. However, many renal stones are asymptomatic and are incidental findings during imaging for other indications.

When pain occurs, it typically waxes and wanes in intensity, lasting 20 to 60 minutes, with a dull pain between bouts of the colicky pain. As the stone moves down the ureter, the pain shifts to the abdomen and ipsilateral groin, and as it nears the ureterovesicular junction, the pain is characteristically in the lower quadrant, radiating to the tip of the urethra, and associated with urinary urgency, frequency and dysuria. Macroscopic haematuria may occur but its absence does not exclude renal stone disease. Patients may have nausea and vomiting.

## DIAGNOSIS AND INVESTIGATION

History taking, examination and investigation aim to confirm the diagnosis and to detect any complications, such as sepsis

or renal damage, and underlying factors that increase the risk of renal stones.

On examination, patients appear distressed, writhing on the examination table in attempts to find a comfortable position. Abdominal examination may reveal tenderness in the costovertebral angle or lower quadrant. Patients may also appear pale and clammy. The presence of fever suggests infection. Signs of peritoneal irritation suggest an alternative diagnosis. Intra-abdominal pathology that can mimic renal colic includes abdominal aortic aneurysm, diverticulitis, appendicitis and gynaecological pathology (Box 2).

The extent of evaluation for patients presenting with a single first stone is debated. History taking should include enquiry about underlying medical conditions, medications and supplements that increase the risk of stone formation, as well as lifestyle factors (see below). Onset in childhood and a strong family history suggest that investigation for specific metabolic disorders is indicated.

## Blood and urine tests

All patients with a renal stone should have at least a limited biochemical 'work up', as outlined in Box 3, to identify any factors that increase the risk of stone recurrence, such as primary hyperparathyroidism. In addition, a midstream urine specimen should be sent for microscopy and culture, particularly looking for infection and the presence of urease-splitting organisms. Urine microscopy may also reveal crystals. Urine pH should be measured; a pH greater



### 3. LIMITED EVALUATION OF A PATIENT AFTER A FIRST RENAL STONE

- Blood tests
  - Urea, electrolytes, creatinine levels
  - Calcium and phosphate levels
  - Uric acid level
  - Parathyroid hormone level
- Urine tests
  - Midstream urine microscopy, culture and sensitivity
  - Urinary pH
- Renal imaging with CT of the kidneys, ureter and bladder (ultrasound or MRI if the patient is pregnant)
- Analysis of renal stone composition

than 7.5 suggests stone formation is associated with infection. A low serum bicarbonate level may indicate an underlying type 1 renal tubular acidosis.

#### Renal imaging

Patients with a history of kidney stones who present with typical symptoms and no signs of complications and have urological follow up arranged may be managed conservatively, with imaging undertaken if this management fails. Patients presenting with the first onset of symptoms suggesting a renal stone, infection or atypical signs and those who do not improve with conservative management should have renal imaging.

A CT scan of the kidney, ureters and bladder (CT KUB) is the preferred option for most patients undergoing renal imaging as it can detect all stone types, including uric acid stones, which are radiolucent and thus not visible on a plain x-ray KUB. For pregnant women with renal stones, an ultrasound examination is preferred but does not adequately image the ureters. MRI may also be used in pregnancy.

For patients with recurrent renal stones, the radiation exposure from repeated imaging must be considered. A 2011 study in

Victoria of 58 consecutive patients undergoing surgery for urinary tract stone disease found that at least 44% had been exposed to high levels of radiation over the preceding year, mainly related to repeated CT scans. The authors concluded that there was a possible long-term increase in the risk of cancer.<sup>9</sup>

#### Analysis of stone composition

Analysis of the composition of renal stones is essential to determine appropriate long-term treatment. Stones should be retrieved for analysis when possible, either at the time of surgical intervention or by having patients recover stones passed spontaneously.

#### Practice tip

- Suggest that patients pass urine into a container and then strain the urine.

### TREATMENT OF RENAL STONES

#### Expectant observation

Nonsurgical management of renal colic involves waiting for the spontaneous passage of a stone. Nonsurgical management may be appropriate for patients with:

- no evidence of sepsis
- good renal function and
- well-controlled pain.

Pain management should be individualised. NSAIDs and opiates are equally effective in the short term. However, NSAIDs should be avoided in anyone with impaired renal function or volume depletion.

A 10- to 14-day trial of tamsulosin has been recommended for patients with renal colic being managed with expectant observation but is not PBS-listed for this indication.<sup>10</sup> Calcium channel blockers may also be of use but are less effective than tamsulosin.<sup>10</sup>

Patients undergoing expectant observation should be instructed to seek prompt review if they develop fever, persistent vomiting or uncontrolled pain. Urological follow up must be in place. Follow-up imaging is required to ensure that the stone has passed.

Expectant observation is undertaken for up to two weeks. Patients who fail to pass a stone within two weeks require active urological intervention.

#### Active urological intervention

Indications for active urological intervention include:

- stone diameter of 7 mm or more
- pain not controlled
- obstruction associated with infection (as there is a risk of pyonephrosis or urosepsis)
- bilateral obstruction or obstruction of a single kidney
- pregnancy (see below).

Obstruction of the urinary tract in the presence of infection is a medical and surgical emergency. If there is sepsis or a risk of sepsis then immediate relief of the obstruction by insertion of a retrograde ureteric stent or radiographic insertion of a percutaneous nephrostomy is essential. After percutaneous nephrostomy, an antegrade ureteric stent may be inserted. A stent is also required to relieve a urinary tract obstruction in pregnant women, with definitive intervention undertaken after delivery. A detailed discussion of the urological management of renal stones is not included in this article.

Primary hyperparathyroidism complicated by renal stone disease is best treated with surgical removal of the adenoma or adenomas.

### PREVENTING RECURRENCES

#### Referral for specialised evaluation and management

Some patients with renal stones require a more detailed metabolic evaluation, which is generally undertaken by a renal physician or urologist with a specific interest in renal stone disease or a specialised renal stone clinic. The indications for referral for a more detailed metabolic evaluation are listed in Box 4.

Analysis of a 24-hour urine collection, in addition to serum biochemistry and urine pH, must be undertaken when the patient has recovered from an acute event

#### 4. INDICATIONS FOR REFERRAL FOR MORE DETAILED METABOLIC EVALUATION

- Presence of multiple renal stones
- Recurrent renal stones
- Strong family history of renal stones
- Onset in childhood
- Intestinal disease (particularly chronic diarrhoea)
- History of urinary tract infection with stones
- Frail or poor health (unable to tolerate repeat stone episodes)
- Solitary kidney
- Anatomical abnormalities
- Renal insufficiency
- Stones composed of cystine, uric acid or struvite
- Pathological skeletal fractures
- Osteoporosis

or intervention such as lithotripsy, generally after two to three months. Patients should collect their urine as outpatients, while consuming their usual diet and fluid intake. The crucial need to maintain their usual fluid intake and diet should be emphasised to patients; unfortunately, some people modify (and generally increase) their fluid intake while collecting the 24-hour urine, which may obscure the key metabolic risk factors for stone formation.

The number of 24-hour collections required for a full metabolic evaluation varies. Although some laboratories are able to undertake a full evaluation on a single 24-hour urine collection, most commercial laboratories require multiple collections, which becomes a significant burden and practical challenge for patients.

Evaluation in a specialised stone clinic also involves a dietitian taking a detailed diet history, estimating intake of protein, sodium, oxalate, calcium and other dietary components, and providing specific dietary advice on foods to avoid or minimise.

Medical management to help prevent stone recurrence in patients with specific stone types and metabolic abnormalities is summarised in Box 5. Patients with recurrent calcium stones may have multiple metabolic abnormalities, which require a more complex combination of therapy to prevent stone formation, such as a thiazide diuretic, allopurinol, potassium citrate and a high fluid intake.

Struvite stones require specialised management. Effective treatment of struvite stones requires removal of all stone material and treatment, if possible, of the chronic urinary tract infection, usually caused by a urea-splitting organism such as *Proteus* or *Klebsiella* spp. This may be extremely difficult, if not impossible, in patients with a long-term indwelling catheter.

#### Advice on lifestyle factors

Lifestyle factors that affect the risk of stone formation and some practice tips to minimise the risk of recurrence are discussed below and summarised in Box 6.

#### Fluid intake and types consumed

A high fluid intake (more than 2.5 L/day) decreases the risk of recurrent stones of all types and is the most important lifestyle intervention to prevent recurrence. Patients with cystine stones require an even higher urine volume, of more than 4 L/day.

The impact of tea, coffee and alcohol on renal stones remains unclear. It is known that caffeine interferes with the action of antidiuretic hormone (ADH), decreasing urine concentration and increasing urine flow. However, black tea may be high in oxalate and ideally should have milk added to bind the oxalate and limit its absorption via the gut.<sup>11</sup> Epidemiological studies suggest that drinking one cup (240 mL) of coffee (caffeinated or decaffeinated) or tea daily may help protect against renal stones in healthy individuals.<sup>12,13</sup>

Alcohol may protect against stone formation by inhibiting secretion of ADH,

#### 5. MEDICAL MANAGEMENT OF PATIENTS WITH RENAL STONES ACCORDING TO STONE TYPE AND METABOLIC ABNORMALITIES\*

##### Calcium stones with hypercalciuria

- Thiazide diuretics (hydrochlorothiazide or chlorthalidone)
- Amiloride
- Potassium citrate
- Low sodium diet

##### Hyperoxaluria

- Cholestyramine
- Vitamin B<sub>6</sub>

##### Low urinary citrate

- Potassium citrate (sodium bicarbonate may be used for patients who cannot tolerate potassium citrate, but the increase in urinary sodium also increases calcium excretion)

##### Hyperuricosuria

- Allopurinol
- Potassium citrate

##### Cystine stones

- High fluid intake
- Urinary alkalinisation
- Tiopronin, D-penicillamine or captopril (sulfhydryl group donors)

##### Struvite stones

- Urological intervention (required)
- Treatment and prevention of urinary tract infections
- Surgery with complete removal of stone

\* Determined by 24-hour urine collection.

decreasing urinary concentration. Wine appears to be more protective than beer, but both are significant sources of calories, and prevention of obesity is likely to have a greater impact on stone prevention. Alcohol should only be consumed in recommended amounts – not more than two standard drinks per day for men and one for women, with at least two alcohol-free days a week. Avoiding alcohol intake may be of benefit to people who develop uric acid stones.

## 6. RECOMMENDED LIFESTYLE MEASURES TO REDUCE RENAL STONE RECURRENCES

- Ensure a high fluid intake to maintain a urine output of at least 2L/day (ideally aiming for 2.5 to 3.0 L/day)
- Avoid dehydration by increasing water intake if sweating profusely; spread water intake over the day and night if awake.
- Reduce dietary sodium intake
- Maintain a normal calcium intake via dietary sources
- In general, reduce total protein intake and increase fruit and vegetable consumption
- For patients with uric acid stones, maintain a high fluid intake, moderate protein intake and no alcohol
- For patients with oxalate stones, we recommend avoiding foods high in oxalate and vitamin C, and consuming calcium-rich foods to bind oxalate and reduce its absorption
- For patients with stones caused by impaired absorption of calcium due to small bowel disease, supplementation with magnesium citrate may be helpful
- Note that vitamin D supplementation may be a risk factor for renal stone disease
- For patients taking a fish oil product, check the label carefully as some of these products contain vitamin D, which may contribute to stone formation
- For patients who have a recurrence of renal stones while taking any herbal or other botanical-based products, we consider it prudent to cease taking these products
- Remember that obesity increases the risk of renal stones, as does weight loss achieved with laxatives or extreme dieting

### Practice tips

- The most effective and simple intervention to prevent recurrent renal stones is to ensure patients have a high intake of fluid (ideally water) that maintains a urine output of at least 2 L/day (ideally aiming for 2.5 to 3.0 L/day).<sup>14</sup>
- Failure of patients to increase their urine output has been found to be a strong predictor for recurrent stone formation in patients followed up in a dedicated stone clinic.
- Fluids that appear from observational studies to increase the risk of stone recurrence include:
  - soft drinks rich in phosphoric acid, such as cola drinks; phosphoric acid reduces urinary citrate and thus binding of oxalate<sup>15</sup>
  - cranberry juice, more than 1000 mL/day; this volume of

cranberry juice decreases urinary pH and increases urine calcium oxalate concentration, leading to uric acid stone formation<sup>16</sup>

- apple juice
- grapefruit juice, which increases the risk of recurrence via an unknown mechanism.<sup>17</sup>
- Fluids that may exert a protective effect include:
  - lemon juice (120 mL/day, mixed with water), which is rich in citrate<sup>18</sup>
  - milk, which exerts a protective effect by binding oxalate in the gastrointestinal tract.<sup>19</sup>

### Work environment and exercise

People who work in hot conditions or undertake heavy physical activity that results in profuse sweating and decreased urine production have an increased risk of dehydration and concentrated urine.

This favours urine supersaturation and crystal formation.

### Practice tip

- People in situations where they sweating profusely require a higher water intake (more than 2.5 L/day) to avoid dehydration and maintain a high output of dilute urine.
- Encourage patients to spread out their water intake over the day and during the night if awake.

### Sodium intake

A high sodium intake (more than 100 mmol urinary sodium excretion in 24 hours) increases urinary calcium excretion. Reducing sodium intake reduces urinary calcium excretion and the risk of stone formation and also increases the efficacy of thiazide diuretics. Higher sodium excretion increases uric acid excretion and decreases urinary citrate concentrations.

### Practice tip

- Suggestions for patients to reduce dietary sodium intake include choosing low-salt packaged products (less than 120 mg sodium per 100 g) and avoiding adding salt to food in cooking and at the table.

### Calcium intake

Calcium binds with oxalate in the normal gastrointestinal tract. A low oral calcium intake increases the absorption of oxalate and the risk of calcium oxalate stone formation. However, an excessive calcium intake can also increase the risk of stone formation. Therefore maintenance of a normal calcium intake as per the dietary guidelines is recommended. The minimum daily requirement for calcium is 840 mg, and the general recommendation for adults is 1000 to 1300 mg/day.

If calcium supplements are used then they are best taken with food. Calcium citrate provides additional citrate, which is a key inhibitor of stone formation. It acts by lowering urinary saturation and inhibiting crystallisation of calcium salts.



### Practice tip

- Patients should maintain a normal calcium intake as recommended for age. Both a low and an excessively high calcium intake increase the risk of stone formation.

### Protein intake

High protein diets (more than 2g/kg) should be avoided. High protein diets increase the urinary excretion of calcium and uric acid as well as reducing citrate excretion.<sup>20</sup>

### Practice tip

- In general, reducing total protein intake and increasing fruit and vegetable consumption will reduce the risk of stone formation.

### Excess uric acid

Uric acid renal stones may form in patients with elevated urinary uric acid excretion associated with gout and elevated serum uric acid levels, and also in patients with normal serum uric acid levels but high tubular leaks of uric acid. A higher risk of uric acid stones has also been observed in patients with obesity, diabetes or metabolic syndrome. In patients with these conditions, the urine is abnormally acidic.

Dietary management of people who develop uric acid stones has changed in recent years. Although uric acid is the major end-product of purine metabolism, restricting dietary purines does not appear to decrease the risk of uric acid renal stones. The major contributing factor to uric acid stone formation is low urinary pH (less than 5.5) rather than elevated urinary uric acid (hyperuricosuria).

A high fluid intake (more than 2.5 L/day) combined with a moderate protein intake (0.8 g/kg/day) and no alcohol have been shown to decrease urinary uric acid excretion in adults.

Allopurinol is indicated for patients with persistently high urinary urate levels who develop urate stones and also those who develop predominantly calcium stones, as urate crystals may form the nidus around which calcium is then deposited.

### Oxalate

Hyperoxaluria may be genetic (primary), which is quite rare, or acquired. We recommend managing patients with genetic hyperoxaluria and those with acquired hyperoxaluria and frequent stone formation at a dedicated stone clinic. For most patients with persistent hyperoxaluria, restricting dietary oxalate is reasonable, although evidence supporting such an approach is limited. Foods that should be limited include:

- green leafy vegetables (spinach, silverbeet, kale, rocket, broccoli, beetroot, rhubarb and Chinese vegetables)
- legumes (soy beans and soy products such as soy sauce, tofu and tempeh, baked beans)
- nuts and nut products such as peanut butter
- fruits such as berries and kiwifruit
- products rich in dried fruit and peel such as marmalade or fruit cake
- cocoa-based products such as chocolate and chocolate-malt drinks
- vegetable and fruit juices containing combinations such as spinach and beetroot or berries.

Patients who develop oxalate stones may also have reduced levels of a gastrointestinal bacterium that breaks down oxalate, *Oxalobacter formigenes*. The implications of this finding remain uncertain.

Consultation with a dietitian is recommended for patients on a low-oxalate diet to ensure adequate dietary variety.

### Practice tips

- Vitamin C in large doses may increase the risk of stone formation because of its conversion to oxalate. Vitamin C must not be taken by anyone with genetic hyperoxaluria and is best avoided or at least limited to 500 mg/day by those with nongenetic forms of hyperoxaluria.
- Patients should be advised to cook vegetables by boiling to reduce their

oxalate content and to consume calcium-rich foods with meals to help bind oxalate and reduce its absorption.<sup>21</sup> This is because individuals who develop calcium oxalate stones appear to absorb intestinal oxalate more readily than healthy individuals.

### Vitamins and other supplements

#### Vitamin C

Vitamin C should be avoided by patients with hyperoxaluria, as discussed above. In addition, a prospective cohort study of Swedish men found that those taking vitamin C supplements had double the risk of renal stone formation compared with those not taking vitamin C, suggesting a need for caution with vitamin C supplementation.<sup>22</sup>

#### Vitamin D

Vitamin D supplementation may be a risk factor for renal stone disease. Several studies have found a positive correlation between serum vitamin D levels and urinary calcium excretion. This correlation is probably a result of increased intestinal calcium absorption, which increases intestinal absorption of oxalate.

In granulomatous conditions such as sarcoidosis, vitamin D supplementation provides an additional substrate for formation of 1,25-dihydroxyvitamin D and may result in hypercalcaemia as well as hypercalcuria and stone formation.

However, vitamin D deficiency can cause secondary hyperparathyroidism. We recommend correcting vitamin D deficiency and thus suppressing secondary hyperparathyroidism. In this situation we recommend obtaining advice from a specialised renal stone clinic and close monitoring of urinary calcium excretion.

#### Magnesium

Magnesium deficiency is associated with increased renal stone formation. Magnesium citrate may be taken by patients who develop stones because of impaired

absorption of calcium caused by small bowel disease.

### Fish oil supplements

Intake of omega-3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) may reduce the urinary excretion of calcium and oxalate. Thus, it has been suggested that a higher intake of EPA and DHA (from either dietary sources or fish oil supplementation) may reduce the risk of renal stones; however, no clinical trials have evaluated the effect of omega-3 fatty acids on the development of renal stones. Patients intending to take a fish oil product should check the labels carefully as some of these products contain vitamin D and may contribute to stone formation.

### Herbal and other botanical products

Specific advice about herbal products and risk of stone formation is difficult because of a lack of information. However, if patients develop recurrent stones while using herbal or other botanical-based products, particularly herbal teas, the prudent advice is to cease taking these products.

### Obesity

Obesity is a risk factor for renal stone formation, particularly in women. Obese patients have a higher incidence of uric acid stones. The metabolic syndrome is associated with a lower urinary pH.

Bariatric surgery and certain types of weight loss diets may also increase the risk of renal stone formation. For example, a small study found that a low-carbohydrate, high-protein diet lowered urinary pH and citrate levels and increased urinary uric acid levels and acid and calcium excretion in healthy subjects. All of these changes increase the risk of stone formation and may increase the risk of bone loss. Excess sucrose intake is also linked with higher calcium excretion.

### Practice tip

- Patients must be informed that losing weight with laxatives or extreme

dieting can increase their risk of renal stones.

## SPECIAL SITUATIONS

### Bladder stones

Bladder stones are usually composed of uric acid in non-infected urine or struvite in infected urine. Most patients with these types of stones have obstruction, which causes them to reduce their fluid intake, resulting in concentrated acidic urine. Calcium oxalate or cystine stones form in the kidneys, pass down the ureter and are trapped in the bladder.

Typical symptoms of bladder stones are intermittent, painful voiding and terminal haematuria. The pain may be dull, aching or sharp suprapubic pain, which is exacerbated by exercise and sudden movement. Severe pain typically occurs near the end of micturition when the stone becomes impacted at the bladder neck. This is relieved when the patient lies flat. Pain may be referred to the tip of the penis, scrotum, perineum and occasionally the back or hip. Impaction of the stone in the bladder neck interrupts the urinary stream.

The main intervention for the prevention of recurrent bladder stones is relief of bladder outlet obstruction.

### Infants

Neonates with frusemide-induced nephrolithiasis present with haematuria, worsening renal function and calcific densities on renal ultrasound or plain film radiography. Nephrocalcinosis is often present. Similar findings have been seen in neonates with severe low birth weight and/or prematurity and no history of loop diuretic usage.

### Children and adolescents

The presence of stones in children and adolescents suggests the possibility of an inherited genetic disease such as cystinuria, renal tubular acidosis or primary oxaluria. With increasing obesity in childhood there is also an increase in the incidence of renal stones.

The medical management is similar to

that in adults with increased water intake. Dietary modifications are similar to adults except for calcium intake, which should be increased via dietary intake of high calcium foods rather than supplementation.

### Pregnant women

Pregnant women with renal stones should be imaged by ultrasound examination or MRI. Metabolic evaluation is not undertaken during pregnancy. Management during pregnancy is generally surgical. Stents are inserted via cystoscopy with minimal radiation.

## CONCLUSION

Renal stones are common. Stone recurrence can be avoided or reduced by addressing lifestyle and dietary factors. Referral for more detailed and specialised management to a specialised renal stone clinic is necessary for some patients. MT

## REFERENCES

A list of references is included in the website version ([www.medicinetoday.com.au](http://www.medicinetoday.com.au)) and the iPad app version of this article.

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# Renal stones

## First steps and keys to reducing recurrence

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